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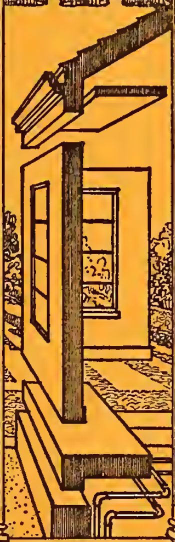


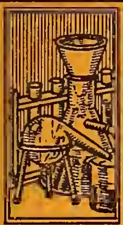
BUILDING MATERIALS AND STRUCTURES

REPORT BMS77

Properties and Performance of Fiber Tile Boards

by

DANIEL A. JESSUP,
HERMAN BOGATY, *and*
SAMUEL G. WEISSBERG



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ISSUED AUGUST 8, 1941

The National Bureau of Standards is a fact-finding organization; it does not "approve" any particular material or method of construction. The technical findings in this series of reports are to be construed accordingly.

UNITED STATES GOVERNMENT PRINTING OFFICE · WASHINGTON · 1941

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Foreword

Fiber tile board offers considerable promise as a finishing material for installations where much more costly materials are ordinarily used. Samples of this type of board were tested as a part of the research program on building materials and structures.

LYMAN J. BRIGGS, *Director.*

Properties and Performance of Fiber Tile Boards

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ABSTRACT

Performance tests have been made on fiber tile boards by subjecting them to conditions which they might possibly meet in service. The properties examined were resistance to abrasive cleaning powders, resistance to staining by household chemicals, and stability of the boards when subjected to cycles of steaming and drying. In addition, data were obtained on the density, expansivity, and flexural properties of the boards, and on the thickness and impact resistance of the finish coatings.

The resistance of most of the boards to staining, to impact, and to abrasive cleaning powders was good. Most of the surface coatings were damaged by the cycles of steaming and drying, especially at the edges, where moisture had direct access to the base material, and at the score marks, where the coatings in some of the boards were very thin. The density, expansivity, and flexural properties were satisfactory.

I. INTRODUCTION

In connection with research at the National Bureau of Standards on building materials and structures relative to low-cost housing,[1] it was considered desirable to include a study of the properties of fiber tile boards. This material is made of vegetable-fiber boards in large sheets, and has on one side a dense, hard coating, either white or colored. The coated surface is frequently scored to resemble the ceramic wall tile commonly used in more costly structures than those for which the fiber tiles are primarily intended.

II. DESCRIPTION OF SAMPLES

The samples were commercial products furnished by manufacturers. They consisted of compressed wood-fiber board, coated on one side with a synthetic plastic. Some of the coatings were homogeneous, and others had a top layer over a priming coat. Two of the products had a resinous binding material in the base boards. There was no added material in the other base boards.

III. PROPERTIES AND TESTING

The samples were tested in their normal condition for the physical properties commonly measured on fiberboards, and for resistance to impact, steam, abrasion, and various liquids since structural tile in use frequently encounters one or more such deteriorative influences. The data are contained in tables 1 and 2, respectively.

[1] NBS Building Materials and Structures Report BMS1 (1938) 10¢. (See page 3 of cover.)

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Table 1.—*Properties of fiber-tile boards*

Board number	Thickness	Density	Linear expansion [b]	Flexural properties [c]				Coating thickness [d]	
				Breaking load		Deflection at rupture			
				Machine	Cross	Machine	Cross	Over all	Top-coat
	in.	*lb/ft*[3]	%	*lb*	*lb*	*in.*	*in.*	*in.*	*in.*
80 [a]	0.140	69	0.15	47	50	0.21	0.21	([a])	([a])
10 [a]	.145	85	.20	79	62	.15	.15	0.0070	0.0070
11 [a]	.140	83	.15	91	74	.15	.15	.0152	.0026
20	.160	76	.10	96	80	.10	.06	.0120	.0022
30	.133	65	.19	42	44	.22	.27	.0028	.0012
40	.144	72	.10	50	53	.21	.23	.0048	.0048
50	.146	73	.13	56	50	.18	.20	.0036	.0036
51	.141	71	.13	51	58	.18	.17	.0064	.0060
52	.143	70	.10	55	66	.18	.20	.0071	.0066
70	.140	71	.15	48	51	.20	.19	.0036	.0036
90	.148	69	.17	56	51	.16	.17	.0042	.0018
91	.148	69	.20	50	53	.13	.15	.0054	.0038
100	.142	70	.25	47	52	.17	.18	.0028	.0028
110	.136	73	.17	50	44	.20	.19	.0044	.0020
111	.140	70	.16	52	48	.19	.19	.0062	.0028
130	.150	67	.15	55	55	.18	.17	.0062	.0062
131	.150	67	.17	57	55	.20	.19	.0036	.0036
140	.139	73	.17	56	57	.20	.18	.0042	.0018
141	.139	73	.14	62	65	.16	.17	.0066	.0066

[a] Samples 10 and 11 are compressed wood fiber with a resinous binder. The remainder of the boards are compressed wood fiber with no added material. Sample 80 has no surface coat and is included for comparison.
[b] For a change in relative humidity of surrounding atmosphere from 50 to 95 percent.
[c] For specimens 1 inch wide on supports 3 inches apart.
[d] Identical figures for over-all thickness and topcoat thickness indicate a board with a single coat.

Table 2.—*Resistance of fiber tile boards to deteriorative influences*

Board number	Resistance to impact [a]				Resistance to steam				Resistance to abrasion	
	Before steaming		After steaming							
	1-oz weight	2-oz weight	1-oz weight	2-oz weight	Extent of warping [b]	Color [f]	Gloss	Blistering of surface [c]	Entire coating [d]	Per 0.001 inch of coating
	in.	*in.*	*in.*	*in.*	*in.*				*Thous. of cycles*	*Thous. of cycles*
10[e]	30	7	34	11	0.400	Good	Poor	*B*	75	10.7
11[e]	29	8	39	8	1.12	Poor	do	*B*	60	3.9
20[e]	40	34	40	31	.172	Fair	do	None	60	5.0
30	13	5	39	14	.135	Good	Good	*E, S*	15	5.4
40	20	8	29	9	.063	do	do	*E, B*	40	8.3
50	18	8	19	4	.126	do	Poor	*S, L*	15	4.2
51	23	6	20	5	.004	do	do	*E*	53	8.3
52	18	7	11	2	.048	do	do	*S, L*	40	5.6
70	7	4	8	4	.035	do	do	*B, E*	20	5.6
90	6	4	9	4	.020	do	Good	*B, E*	15	3.6
91	7	4	7	4	.045	do	do	*B, E*	15	2.8
100	13	3	20	9	.031	Poor	Fair	*B, S*	4	1.4
110	14	10	34	12	.033	do	do	*B, S*	20	4.5
111	16	5	29	10	.050	Good	Good	*B, E*	15	2.4
130	8	7	24	14	.040	do	Poor	*S*	6	1.0
131	10	6	25	14	.040	do	do	*E*	17	4.7
140	10	6	34	14	.022	Poor	do	*B, E*	8	1.9
141	6	3	15	4	.007	Good	Fair	*B, E*	24	3.6

[a] Impact tests were made by dropping a cylindrical weight on the surfaces of the boards placed at 30° to the horizontal. The values recorded are the shortest distances required to break the surface.
[b] Measured at the center of a 12-inch span.
[c] The letters indicate the places where the blistering effect was noted: *B*=on broken surfaces, *E*=at edges of the board, *S*=at score marks, *L*=loosening of the coating.
[d] Number of thousands of cycles of scrubbing with a cloth pad, soap and water, and mild household cleanser to wear coating through to base material.
[e] Samples 10, 11, and 20 were not stained by writing ink, 5 percent acetic acid, tincture of iodine, or hot grease. The remaining samples were stained only by 5 percent acetic acid and by commercial tincture of iodine.
[f] Samples 10, 40, 50, 51, 52, 70, 90, 91, 130, 131, and 141 had white surfaces; samples 30, 50, 51, 52, 70, 91, 100, 110, and 130 were scored to resemble ceramic tile.

1. Thickness and Density

The density of the tile board is the weight per unit of volume. It was computed from measurements of dimensions and from determination of weight. In most cases specimens about 18 by 18 inches were used. The weight was determined on a torsion balance reading to 0.1 gram, and the thickness was determined by means of a micrometer caliper reading to 0.001 inch.

2. Linear Expansion With Change in Humidity

The change in dimensions with a change in the relative humidity of the surrounding atmosphere is an important characteristic of interior finishing materials. Low expansivity minimizes the difficulties encountered with waving, buckling, and opening of seams when extreme humidity conditions occur.

The linear-expansion tests were made in accordance with the Federal Specification for fiber insulating board.[2] Test specimens measuring about 12 by 2 inches were conditioned in an atmosphere at 50-percent ralative humidity and then conditioned for 48 hours in an atmosphere at 95-percent relative humidity. The changes of length were determined from the displacement of reference marks placed about 8 inches apart on the specimen.

3. Flexural Properties

Although tile boards are not generally required to contribute to the strength of a structure, the boards must be of sufficient strength to withstand, without undue breakage, handling incidental to installation, and to resist damage after installation. The strength of fiber building boards is generally determined in terms of flexural properties. These were determined by placing a specimen 1 inch wide across two parallel supports 3 inches apart and loading at the midspan. The load is conveniently applied by means of a tensile testing machine with suitable fixtures. The rupturing load and the deflection at instant of rupture are recorded. This method is one developed at the Bureau for use with binders board.[3]

[2] Federal Specification LLL-F-321a Fiber Boards; Insulating.
[3] Paper Trade J. **95**, No. 16, 183 (Oct. 20, 1932).

4. Thickness of Coating

The thickness of the coating was determined by an adaptation of Mesle's chord method. This method has been used successfully for the measurement of the thickness of plated metal coatings.[4]

A precision grinding wheel of known radius, R, is lowered upon the surface of the tile board with the axis of the wheel parallel to the plane of the board, as illustrated in figure 1. The

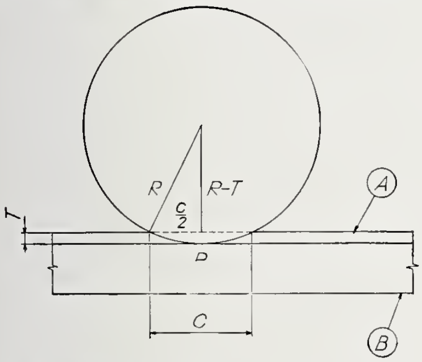

Figure 1.—*Relationship between radius of grinding wheel and thickness of coat.*

A, surface coat; *B*, base material.

surface of thickness, T, is ground through until the wheel reaches the base material along a line through P. The width of the cut, C, is related to the thickness, T, and the radius of the grinder, R, as follows:

$$R^2=(R-T)^2+\left(\frac{C}{2}\right)^2 \text{ or } 2\,RT=T^2+\frac{C^2}{4}.$$

As T is about 0.01 inch, R about 4 inches, and C about 0.5 inch, T^2 may be neglected, making $T=(C^2/8R)$.

In practice the plane of the specimen is tilted so that it makes an angle of about 1° with the axis of the wheel. This gives a cut with a semielliptical plan (fig. 2). Tilting has the advantage that, when there is more than one layer of coating, all are exposed for measurement with but one grinding operation. Moreover, there is no uncertainty as to the endpoint of the grinding operation. The width of the cut, C, for a particular coating is measured at the apex of the ellipse formed by the intersection of the wheel with the plane separating the coating under consideration from the next lower layer.

[4] J. Research NBS **16**, 171 (1936) RP866.

5. Effect of Steam

A test was devised whereby the surface of the fiber tile was exposed to the action of condensing steam for 7 hours and then allowed to dry for 17 hours. Changes in appearance and properties were determined after five such cycles of steaming and drying. The changes produced in some of the boards as a result of this treatment are shown in figures 3, 4, and 5.

Warping was determined by means of a cylindrometer. This device consists of two rigid feet fixed 12 inches apart and a movable foot attached to a dial micrometer at the center of the span. A zero reading is obtained by holding the instrument on a plate-glass surface. The difference between the micrometer reading on the warped board and the zero reading gives the degree of warping.

The warping was extreme in only two of the samples. The base material of these was compressed wood fiber with a resinous binder.

The resistance of the coating to change of gloss and color after steaming was rated as

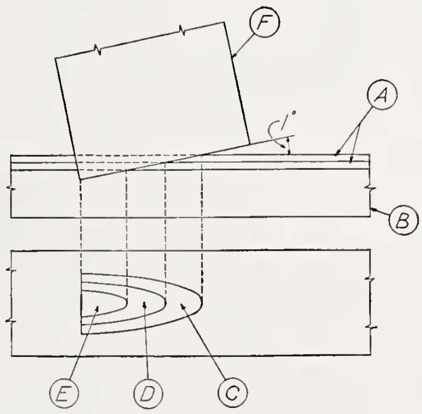

Figure 2.—*Appearance of the cut on the surface of the fiber tile board.*

A, surface coatings; *B*, base material; *C*, exposed top coat; *D*, exposed under coat; *E*, exposed base material; *F*, grinding wheel.

follows: Good, no change; fair, slight but not objectionable; poor, considerable change.

Most of the boards became less glossy on steaming and many of the colored boards faded (fig. 3). In general the color of the white boards was unaffected by steam.

The coatings of most of the boards underwent some surface change. Steaming caused wheals or blisters to form, generally at the edges, near score marks, or at places where the coating had

FIGURE 3.—*Color change produced by steaming.*

Unexposed portion is so marked

been scratched or broken (fig. 4). In two instances the coating loosened and tended to separate from the base (fig. 5).

6. Impact Tests

Impact tests on the coated surfaces of tile boards were used as a measure of the resistance to chipping by hard blows. Specimens were placed in a metal frame at an angle of 30° with the horizontal, to simulate glancing blows, and weights were allowed to fall on the surfaces. The shortest distance of fall required to break the surface was recorded. The weights were hardened steel cylinders, ½ inch in diameter, with the edges rounded to a radius of 0.025 inch. The cylinder axis at the moment of impact was vertical. Tests were made with 1- and 2-ounce weights on both the original and the steam-treated boards.

The surface in most cases showed no deterioration after steaming with respect to resistance to impact. The coatings in many instances appeared to be toughened by steaming.

7. Resistance to Abrasion

The surface was tested for resistance to abrasion by mechanically scrubbing it with a cloth-faced pad moving with a reciprocating motion. A device was constructed whereby a number of specimens could be tested simultaneously. The scrubbing pads were composed of wood blocks 2¼ inches square covered with a piece of wool blanket over which was fastened a piece of sturdy twill cloth. A load of 1¼ pounds was applied to the pads. The stroke of the pads was 4 inches, and the rate of scrubbing was 2,500 cycles per hour. The specimens, fixed in place beneath the moving pads, were moistened from time to time with a 1-percent soap solution

to which a mild household cleaning powder had been added.

Change in gloss could not be used as a measure of resistance to abrasion, because the polishing effect of the scrubbing prevented change of gloss. The best indication of resistance to abrasion appeared to be the number of cycles necessary to cause the coat to wear completely through to the base. This criterion was used since, in practice, the board tiles might not have to be replaced until this occurred. As might be expected, there is a fairly good correlation between the resistance to abrasion and the overall thickness of the coat.

8. Resistance to Staining

The resistance of the coating to staining by common household materials was tested by placing ½ milliliter of the following liquids on the surfaces: a 5-percent solution of washing soda, 5-percent solution of acetic acid, commercial tincture of iodine, commercial writing ink, hot bacon grease. The drop was allowed to stand for ½ hour and then wiped with a clean cloth, using soap and water, if necessary, for thorough cleaning. Most of the boards were stained by dilute acid and iodine. The other compounds had no appreciable effect on the coatings.

IV. SUMMARY AND CONCLUSIONS

The tests of the fiber tile boards studied showed that they are very dense, have a moderate degree of expansion with change in moisture content, and are strong and rigid. The thickness of the coating varies considerably.

The resistance of the coatings of the boards to abrasion was excellent, particularly for those having double coatings.

Steam did not adversely affect the resistance

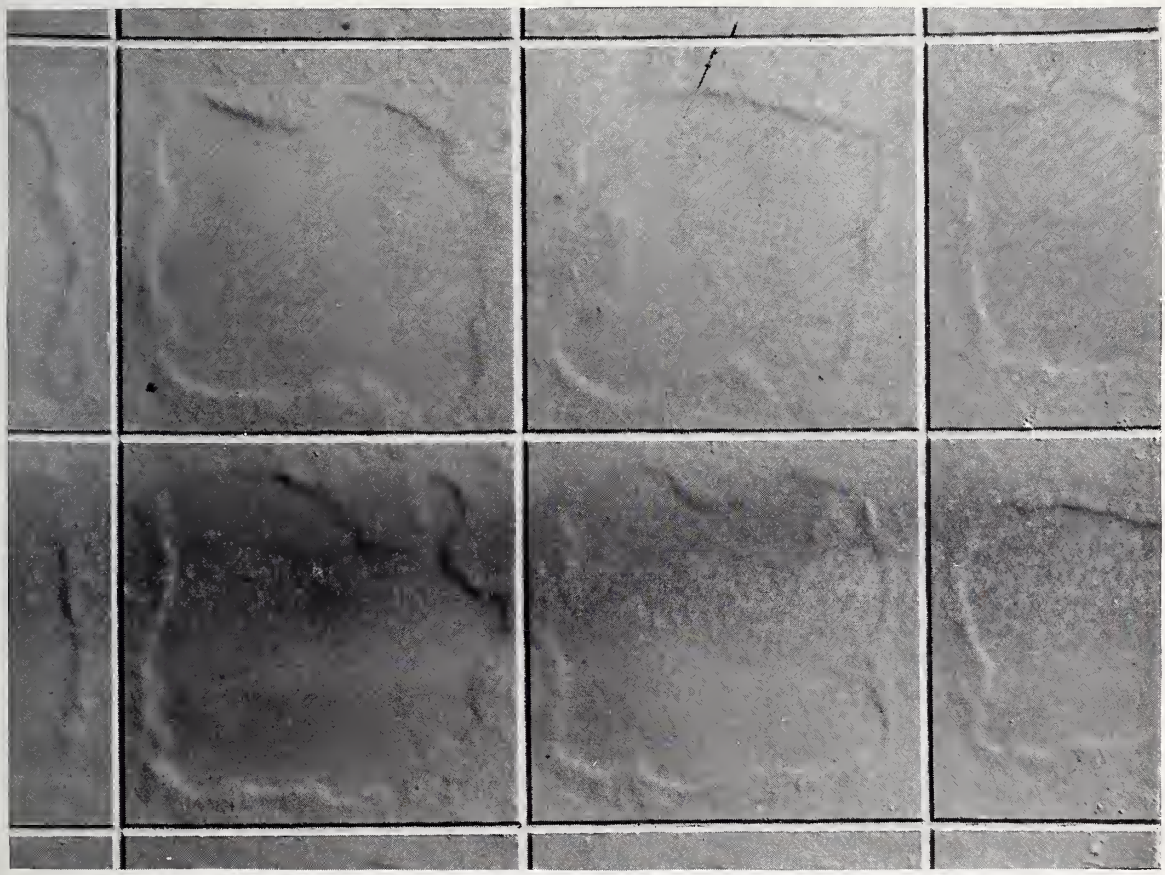

Figure 4.—*Blistering at score marks, caused by swelling of base material when subjected to steam.*

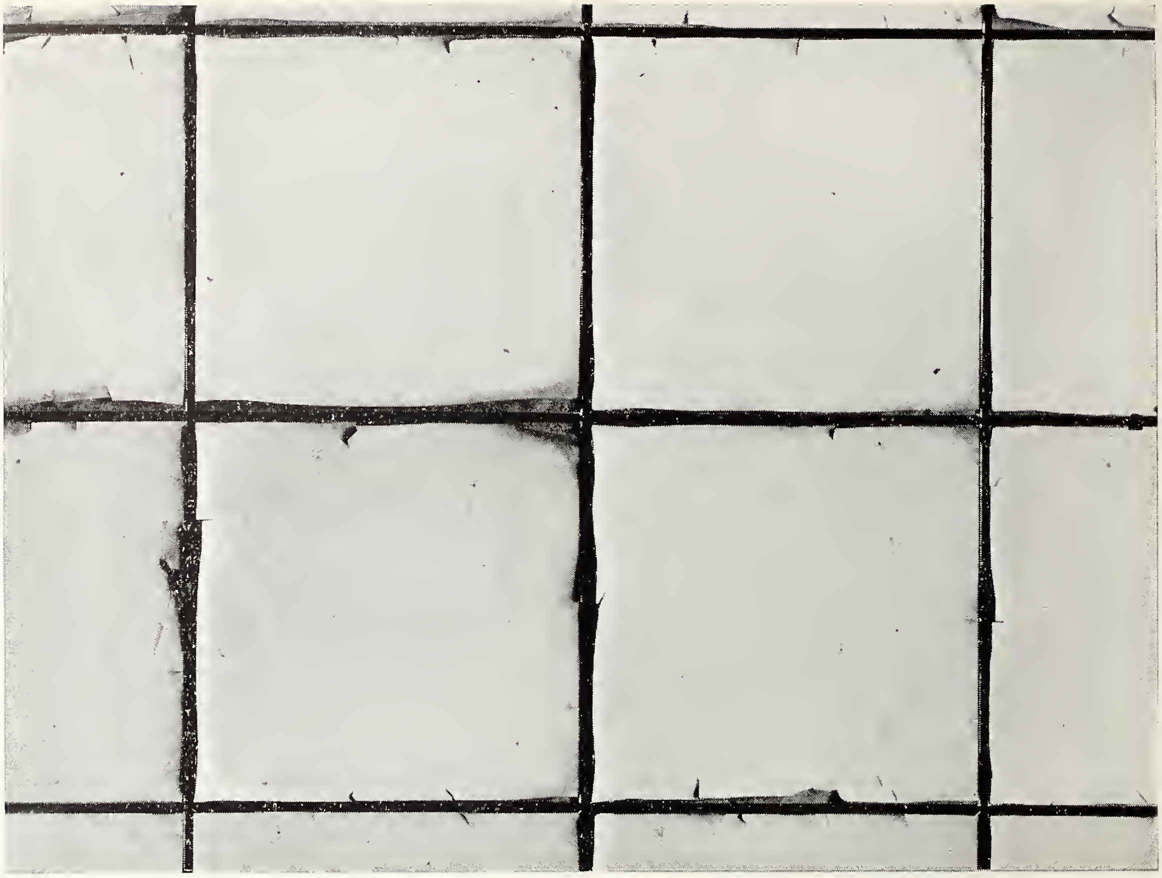

FIGURE 5.—*Loosening of surface coat due to failure of bond between surface coat and base material when steamed.*

of the coatings to impact, but the gloss of most of the coatings was dulled and the colored ones faded. The steaming in general did not affect the color of the white coatings. All coatings treated with steam were blistered, this generally occurring at the edges of the board, near score marks, or where the coating had been scratched. Steam produced excessive warping of two of the boards. The coatings were resistant to staining by writing ink and hot grease, but most of them were stained by weak acetic acid and by tincture of iodine.

WASHINGTON, *May 20, 1941.*

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